There is one component of a DTV receiver, however, that has been incredibly stubborn in resisting the driving force of Moore's Law and other innovations in manufacturing technology. That component is the display:

• The *display* is the critical component when it comes to meeting the central goal that was stated when the advanced television process was launched by the Commission in 1987--to double the resolution of NTSC;

• The *display* is the critical component when it comes to building affordable television receivers that will provide a sufficiently improved viewing experience to encourage the rapid migration to DTV;

• The *display* is the critical component when it comes to delivering the HDTV viewing experience--defined by HDTV equipment manufacturers as an image that covers at least a 35 degree field-of-view with greater than 22 cycles per degree resolution at a viewing distance of approximately three picture heights.

During the SIGGRAPH ATV panel, Mark Richer noted that industry experts have been saying that we will have affordable HDTV displays in ten years. They said this in the '70s...they said it again in the '80s...they are still saying this today. Unfortunately, this is not a problem that Moore's Law can solve. The HDTV viewing experience is very demanding--only the privileged few can afford a system that delivers this experience today. And even if it were affordable, most homes could not accommodate a display that takes full advantage of the proposed 2 Mpixel formats. At a viewing distance of nine feet, a 16 x 9 display with a screen diagonal larger than 100 would be required to deliver the HDTV experience; on smaller screens 2 Mpixel resolution would be wasted. Frankly, a 1 Mpixel, 720 line progressive scan display is more than adequate to deliver the HDTV viewing experience in the typical consumer viewing environment; a 480 line progressive scan display can deliver a sharp image on display of up to a 50" diagonal.

All of these calculations were included in the SMPTE Task Force Report on Digital Image Architecture--the relevant portions of that report were included in an article attached as an appendix to the comments filed by PCUBE Labs to the 5th NPRM.

Two Mpixel formats are primarily of interest in large audience viewing environments and for HDTV and film production systems. It is desirable to produce content in higher resolution for large screen presentation and to protect the archival value of the programs...perhaps someday we will all have homes with a room designed for large screen home theater systems.

It is unreasonable, however, to set 2 Mpixel formats as the target for a mass media television broadcast standard. Only a handful of computer workstations are equipped with displays that offer anything close to 2 Mpixel resolution; several were on display at SIGGRAPH with price tags starting at about $18,000. 1 Mpixel resolution is now achievable with computer displays that cost less than $1,000; the most affordable displays (640 x 480) offer only 1/3 Mpixel resolution. Yet, even these displays nearly meet the original design goal of the ATV process, a doubling of NTSC resolution.

Double the resolution of NTSC resolution falls far short of what is being proposed for HDTV. The NTSC luminance bandpass is 4.2 MHz, thus twice the horizontal resolution would be 8.4 MHz. Shannon's sampling theorem suggests that images should be sampled at twice the highest frequency that we wish to reproduce. Thus the sample rate to double the horizontal resolution for a 60 field system would be 16.8 MHz; if the camera operated at 60 frames per second (progressive scan) this number would be doubled to 33.2 MHz. If the analog signal produced by the Matsushita 480 line progressive scan camera, recently demonstrated at the Commission, were sampled using square pixels (848 x 480) the sample rate would fall very close to 33.2 MHz. If the aspect ratio were increased to 2:1 (960 x 480), the sample rate would increase to 36 MHz. This rate is about half of what is being proposed for 1080 line interlace at 60 fields per second, and 1/4 of what would be required for 1080 line progressive scan at 60 frames per second.

With respect to vertical spatial resolution, double the resolution of NTSC can "effectively" be delivered simply by switching from interlace to progressive scan. ATV proponents and opponents have argued for years about Kell and interlace factors. However, the facts are clear on this subject: for an interlaced system resolution must be halved to totally eliminate small area flicker and twitter in the presence of vertical motion; and 1080 line interlace delivers less vertical resolution than 720 line progressive, no matter how one calculates the Kell or interlace factor.

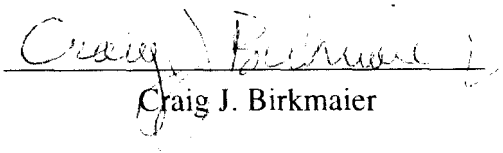
"Double the resolution of NTSC" is an *artifact* of the 1125/60 interlace system developed by Japan's NHK. This system was designed to deliver twice the vertical resolution of NTSC--the latest generation of 1125/60 cameras deliver four or five times more horizontal resolution than NTSC--perhaps a bit less when one considers the additional picture information in the 16 x 9 image versus the 4:3 aspect ratio of NTSC.

848 x 480 (square pixel) progressive scan comes very close to meeting the criteria for "double the resolution of NTSC," not to mention the fact that it also delivers one third more picture information due to the wider aspect ratio. It is also clear that 1280 x 720 significantly exceeds the original target. Put this together with the fact that adequate 2 Mpixel displays cannot be produced at a mass market price, and one must seriously question why 1080 line formats are even being considered for a mass media digital television standard.

3.0 Conclusion

These comments serve to re-enforce the position taken by PCUBE Labs in the original comments filed with the Commission in response to the 5th NPRM.

The Commission should encourage the participants to develop a modular, layered architecture that can be freely extended as the underlying technology evolves. The Commission should encourage the immediate formation of a suitable cross-industry group to deal with these issues and ask for a preliminary report form this group to be delivered by January 1, 1997. The commission should provide a representative to sit as an ex-officio member of the group to enhance communications between these bodies and expedite requests for information regarding FCC policies and regulations.

Respectfully submitted, 

Craig J. Birkmaier

PCUBE Labs
4607 N.W. 6th Street, Suite 3D
Gainesville, FL 32609

August 12, 1996